



Infectious Disease Epidemiology Section
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SALMONELLOSIS

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Salmonella are enterobacteriaceae divided in 7 groups based on DNA similarity and host range: Group 1, *Salmonella enterica* includes the majority of human isolates. Group 3, *Salmonella arizona* replaces the old Arizona genus. Six groups may infect humans. The old division in 3 species (*S. typhi*, *S. cholerae-suis* and *S. enteritidis*) is no longer valid.

Within *S. enterica* there are 2,213 serotypes (1997) based on analysis of the somatic antigen (O) and flagellar antigen (H). These serotypes are given a name: for example *S. enterica* serotype *typhimurium*, often abbreviated as *S. typhimurium*. Of the 2,000 serotypes, some 200 are usually found in humans. The following presentation does not include *S. typhi* and *S. paratyphi* responsible for typhoid fever.

Epidemiology

The primary habitat of *Salmonella* is the intestinal tract of mammals (cattle, swine, rodents, dogs, cats), birds (poultry), reptiles (lizards, iguanas, turtles), amphibians and insects. The majority have a wide range of possible hosts, a few types have a narrow range of hosts: *S. pullorum*, *S. gallinarum* and *S. heidelberg* in chickens, *S. java* and *S. litchfield* for turtle. All types are potentially infectious to humans.

Although *Salmonella* do not form spores, they are fairly resistant in the environment: they survive up to 200 days in contaminated soil, 10 months in dust and more than 4 years in dried egg. They resist freezing and survive acidic pH of 4.5.

The relation with their hosts may vary: some are very well tolerated, some cause a mild gastrointestinal disorder, others a severe enterocolitis or systemic invasive disease that could lead to death.

From the intestinal tract of animals, *Salmonella* are distributed throughout the environment. They can be found in the soil, dust, sewage, rivers, seawater and drinking water.

Prevalence of *Salmonella* in food varies considerably: In a study carried out in 1998 in Washington DC, White (NEJM 2001 345:1147) found 20% of ground meat samples contaminated, including 13 serotypes of resistant *Salmonella* strains particularly multi-resistant *S. typhimurium* DT 104 and DT 208.

The main mode of transmission of *Salmonella* is by ingestion of food derived from contaminated animals or food products contaminated by an infected animal or person. The most frequent sources are:

- Poultry
- Eggs
- Meat
- Dairy products

Salmonella are transmitted through the ovary so that fresh eggs are infected when they are laid. A survey done in 2000 estimated that 1/10,000 eggs contains *Salmonella* while 60-80% of chicken and turkeys harbor *Salmonella*.

Up to 90% of *Salmonella* infections in the US are foodborne in origin (Cohen 1986). The typical foodborne transmission is the result of 2 events:

- 1-The first is the contamination of the food product,
- 2-The second one is the handling that allows sufficient bacterial growth to reach an infectious dose.

Food products become contaminated through several mechanisms:

- Contamination due to bacteremia prior to slaughter,
- Contamination of meat by fecal material after slaughter,
- Use of contaminated ingredients during food processing,
- Cross contamination in the food processing plant,
- Cross contamination in the kitchen during food preparation.

Milk is an important source of *Salmonella* in countries that do not maintain proper milk sanitation. With pasteurization of milk and proper food storage, milk should no longer be a source of *Salmonella*. Those who still drink raw milk are still at risk, particularly from *Salmonella dublin* which is adapted to cattle. In rare occasions, *Salmonella* were found in powdered milk (2% of samples in the US in the 1980's). Improper practices in the preparation and packaging of powdered milk may lead to contamination.

Food handlers may be carriers of *Salmonella*. During food break investigations, food handlers may be found with *Salmonella*. However, they are probably infected from the food rather than being the cause of the foodborne outbreak. In England only 2% of 566 outbreaks of *Salmonella* were related to a food handler. Overall, foodhandlers play a very minor role in the epidemiologic picture.

Water borne outbreaks occur when the drinking water becomes contaminated and is not or insufficiently chlorinated. In a case control study carried out in the Dammam area in 1994, it was shown that *Salmonella* was associated with water being trucked to the house (71% of cases and only 16% of controls had water trucked in, Odds Ratio =30 CI 6.6-225). It appears that water delivered by the trucks may come from unidentified sources that may not be properly chlorinated.

Direct contact with infected animals is an occasional route of transmission. In urban areas, household pets may be sources of infection. Pet turtles, snakes, salamanders, reptiles and aquarium fish have been responsible for some sporadic cases. Pet birds may also be incriminated.

Direct person to person contact has been demonstrated in hospitals, nurseries and long term care facilities. This mode of transmission is more likely to cause illnesses when the recipients are severely ill or immunocompromised. Although person to person spread is frequently suspected in institutions, it was rigorously demonstrated that these are few, most are due to food products of animal origin. Good hygienic practices have been shown to be effective to prevent transmission. In a hospital outbreak, 200 nurses had been infected while partaking in a “nurses’ appreciation dinner”. There were no secondary cases among patients.

The most important person to person transmission occurs from infected mothers to their infants. Neonates have relative achlorhydria and ingest large amounts of milk and formula with large buffering capacity. A mother who has not properly washed her hands will deliver a low dose of *Salmonella*, but this low dose may go through the stomach easily and cause infection.

Airborne transmission does not seem to play any role. Contamination of fomites such as toys, towels may in some occasion be responsible for transmission to a few individuals.

Infective dose does play a role. In experiments with volunteers, the inoculating dose had to be large for causing severe clinical illness (from 100,000 to 10 billion bacteria). A small dose of *Salmonella* (<1,000) will cause only a transient asymptomatic intestinal colonization. The vehicle of infection is important.

Under usual stomach conditions, the number of viable *Salmonella* will be rapidly reduced in the stomach, 10 to 100 fold reduction within minutes. *Salmonella* carried by liquids are more infectious since the transit time in the stomach is reduced. Food that buffer the stomach contents such as cheese, milk and chocolate will protect the bacteria from gastric acidity. Disruption of the normal intestinal flora increases susceptibility to *Salmonella* infection.

Each year an estimated 1.4-2.5 million people in the USA are infected with *Salmonella* and about 600 die.

The incubation period varies between 6 and 48 hours. It depends on the type of *Salmonella* but mostly on the infecting dose: the higher the dose, the shorter the incubation and the most severe the clinical illness.

Clinical Description

The disease has varying degrees of severity. *Salmonella* infections may result in completely asymptomatic carriage, mild gastroenteritis, enterocolitis, and bacteremia isolated or associated with focal infections (meningitis, osteomyelitis and abscesses.)

Asymptomatic carriage is detected by systematic stool examination. For detection of carriers, examination 3 to 10 grams of stools is more productive than rectal swabs. Stools should be inoculated on the proper enrichment medium. Since excretion is intermittent, stool culture should be done over several days. Given these restrictions, detection of asymptomatic carriers is not a very effective control measure.

Mild gastroenteritis: The patient experiences a mild diarrhea with some nausea and abdominal pain which last a few days. Such patients often do not seek medical treatment. In a community where access to medical care is easy these patients turn up for treatment. The diagnosis is made on the basis of isolation of *Salmonella* from stool cultures.

Acute enterocolitis is characterized by a sudden onset of headache, abdominal pain, diarrhea, nausea and vomiting. Fever is almost always present. If diarrhea is severe, dehydration may occur. After a few days the symptoms gradually improve.

Bacteremia occurs in 2% to 10% of cases.

Chronic carrier: After enterocolitis, fecal excretion will persist for several days or weeks. Antibiotics do not decrease the duration of excretion of microorganisms. Long term chronic carriers are rare in non typhi *Salmonella* infections (0.2 to 0.5%) in contrast with 1-5% for *S.typhi* infections. The approach to these carriers depends on their physical status, biliary tract pathology and risk to public health. Long term ampicillin (3-4 weeks) treatment has been advocated for long-term carriers with no biliary pathology and with ampicillin sensitive strains who pose a risk to public health. Those with gall bladder pathology should be treated for their gall bladder problems. There is no systematic recommendation for treatment of carriers, cases have to be handled individually.

Laboratory Tests

Culture

Stool specimens should be collected on cotton tipped swabs and swabs placed in a tube of Cary-Blair culture medium. (These can be obtained from the regional laboratories.) Specimens in Cary-Blair should be refrigerated and transported to the lab under refrigerated conditions as soon as possible. (If necessary to hold 48 hours or longer, freeze sample at -7°C and transport to lab in frozen state.) Complete a Bacteriology Lab Slip (Lab 93).

Food samples that are sent in should be handled by the sanitarian. In the absence of a sanitarian, submit at least 100 grams (approx. 4-5 oz.) of each suspected food item (in separate containers). Be sure to keep food refrigerated (not frozen). Complete Food and Drug Lab Slip (Lab 47).

It will take at least 72 hours until culture results are available. In order to adequately investigate and identify the cause of the outbreak, it is very important to obtain samples of the suspected food and several stool specimens. Confirmation of the causative organism(s) cannot be made with just one of these components.

Serotyping

Submit isolate on appropriate media and complete a Bacteriology Lab Slip (Lab 93)

Interpretation:

1. A case of salmonellosis is confirmed by the isolation of *Salmonella* from any site regardless of symptoms.
2. Serotypes will be reported by serotype name.

Treatment

Treatment of patients with mild gastroenteritis due to non-typhi *Salmonella* strains is not recommended because treatment

- does not shorten the length of disease,
- does not reduce the severity of mild gastroenteritis,
- usually prolongs the duration of excretion
- increases the rate of bacteriologic relapse(s)
- promotes the excretion of resistant strains

However, patients at high risk of invasive disease (e.g. infants <3 months old, hemoglobinopathies, malignancies, immunosuppression, chronic gastro-intestinal diseases) and those with severe symptoms should be treated. The goal of treatment is to prevent invasive disease.

Ampicillin and trimethoprim sulfamethoxazole were recommended but resistance to these antibiotics is nowadays very common. In adults fluoroquinolones are often used and extended spectrum cephalosporins (ceftriaxone) are used in children.

Surveillance

Salmonellosis is a condition reportable within 5 business days of diagnosis.

Case Definition

Clinical description

An illness of variable severity commonly manifested by diarrhea, abdominal pain, nausea, and sometimes vomiting. Asymptomatic infections may occur, and the organism may cause extraintestinal infections.

Laboratory criteria for diagnosis

Isolation of *Salmonella* from a clinical specimen

Case classification

Probable: a clinically compatible case that is epidemiologically linked to a confirmed case

Confirmed: a case that is laboratory confirmed

Comment

Laboratory-confirmed isolates are reported to CDC via the Public Health Laboratory Information System (PHLIS), which is managed by the Foodborne and Diarrheal Diseases Branch, Division of Bacterial and Mycotic Diseases, National Center for Infectious Diseases, CDC. Both probable and confirmed cases are reported to the National Notifiable Diseases Surveillance System, but only confirmed cases are reported to PHLIS. Both asymptomatic infections and infections at sites other than the gastrointestinal tract, if laboratory confirmed, are considered confirmed cases that should be reported to PHLIS.

Investigation

Most cases of *Salmonella* do not need to be investigated because investigation yields very little information usable for preventing purposes. Most cases of *Salmonella* are reported days or even weeks after onset of infection. Recall of food consumption is poor and without large comparison groups, food consumption does not provide useful data.

In some cases, particularly outbreaks, rare serotypes with known association with specific animal sources, and nationally recognized serotypes associated with specific exposures an investigation is warranted.

When an investigation is undertaken, the purpose is to identify cases, to determine the *Salmonella* type (species), to determine the source and mode of transmission (whether from person to person or by common vehicle), to identify the population exposed to increased risk of infection and to institute disease control measures.

Contact the physician, laboratory or hospital to confirm the diagnosis.

Request to submit the stool isolate to the nearest public health laboratory for serotyping.

Determine if the person with salmonellosis (or any ill contacts) is in a high-risk setting (such as an employee of a child care center or a foodhandler). If no high-risk setting is identified, then no further action is necessary.

Child care center, institution, nursing home, etc.

- Determine if any of the staff or attendees/residents are symptomatic.
- Refer symptomatic persons for testing (exclude these persons from child care if the diarrhea cannot be contained in a diaper); if a large number of stool samples will be sent to the state lab for testing, please notify the lab prior to submitting the specimens.
- Discuss routes of transmission and recommended control measures with the staff (use the salmonellosis fact sheet as necessary) and stress the importance of thorough handwashing after toilet use/assistance, between diaper changes, before eating, and before handling/preparing food
- Ask the director to monitor attendees/residents and staff for additional cases.
- Monitor/review reported salmonellosis cases for a connection to the case in the child care center, institution, nursing home, etc.

Foodhandlers

- Determine if any of the staff or patrons are symptomatic.
- Refer symptomatic persons for testing (exclude any symptomatic persons from food handling); if a large number of stool samples will be sent to the state lab for testing, notify the lab prior to submitting the specimens.
- Determine the food handling role of the person with salmonellosis and assess his or her hygiene habits (such as handwashing, personal cleanliness, not working while ill, etc.).
- Discuss routes of transmission and recommended control measures with the staff (use the salmonellosis fact sheet as necessary); stress the importance of thorough handwashing after toilet use, before eating, and before handling/preparing food and the need to not work while ill (especially with vomiting and/or diarrhea).

Other circumstances in which further evaluation may be necessary

- If a physician requests family members be tested
- If follow-up is requested by the Infectious Disease Epidemiology Section
- If the case is suspected to be part of an outbreak

Exclusion

Exclude symptomatic individuals from foodhandling and from direct care of hospitalized and institutionalized patients. The excluded individual should submit two (2) consecutive negative stool cultures collected not less than 24 hours apart (and 48 hours after the last dose of antibiotics, if used) before being allowed to return to work.

If the case is associated with a child care center (either attendee or staff member), contact the day care center owner/director to notify her of the case and to determine if any other cases have occurred. The normal procedure to follow includes testing symptomatic individuals if a second case has been confirmed. Once the laboratory test results are available on those persons, a decision can be made regarding further testing and referral. This should be discussed with the Infectious Disease Epidemiology Section. The Infectious Disease Epidemiology Section has recommended that the child be excluded until the diarrhea is gone or the diarrhea can be contained in a diaper or the child has been cleared by the child's physician or health department.

Prevention

Since most cases of *Salmonella* originate from food, careful preparation of food is the main prevention. *Salmonella* are killed at 60 °C for 15-20 minutes. Cross contamination is very frequent in the home and restaurant kitchen and although the food has been properly cooked, it becomes contaminated after cooking.

1-Education of public focuses on the simple messages below:

To eliminate *Salmonella*:

- Cook food properly
- Avoid cross contamination in the kitchen

The main themes are:

-Handwashing: before, during and after food preparation.
Wash hands with hot soapy water for at least 20 seconds.

-Cooking: Cook thoroughly all food, particularly poultry, eggs and meats

-Refrigerating: Refrigerate perishable food items as soon as it is brought home from the store and keep them refrigerated until used. Do not keep food out of the refrigerator for more than 1 hour, before preparing it. Refrigerate prepared food items if not consumed immediately. Avoid refrigerating large quantities in a single container (the center will remain warm for a long time).

-Thawing frozen food: Thaw frozen poultry slowly in a cold environment (cold water or refrigerator) or rapidly in a microwave. Do not thaw slowly at room temperature (that would foster multiplication of bacteria).

-Reheating: All foods that require reheating must be heated to at least 75C (165F).

-Avoid recontamination in the kitchen. Do not reuse pots, pans, utensils that were used for raw food items with the cooked foods without prior washing them thoroughly. Do not use the same cutting board for raw meat products and raw vegetables.

-Cleaning up: Wash utensils and work area before and after contact with raw food products.

Eggs and poultry are often the source of *Salmonella*. The following are recommendations that could be discussed with patients who are diagnosed with *Salmonella* infection.

When purchasing and storing eggs:

- Buy eggs with clean and uncracked shells. Buy only the quantities needed for one week at a time.
- Refrigerate the eggs as soon as they are brought home from the store and keep them refrigerated until used.

When cooking eggs:

- Avoid serving or preparing foods containing raw eggs. Home made mayonnaise for example is prepared from raw eggs.
- Fried eggs should be cooked on both sides or in a covered pan. The egg should be cooked until the white is firm and the yolks begins to thicken.
- Scrambled eggs should be cooked until firm throughout.
- Batters and mixes that contain eggs are not safe until they have been cooked. Do not let children clean the bowl or eat the uncooked mix.
- All egg-containing foods that require reheating must be heated to at least 75°C (165°F).

Handling eggs and poultry:

- Do not keep raw or cooked eggs or egg products out of the refrigerator for more than 1 hour, including time to prepare and serve (not including cooking time).
- When refrigerating a large amount of egg-containing food items, divide it in several small containers so that the temperature will fall rapidly.
- Refrigerate poultry immediately. Do not keep in the refrigerator for more than 1 week. Frozen poultry on the other hand can be kept in the freezer for months.
- Thaw frozen poultry slowly in a cold environment (cold water or refrigerator) or rapidly in a microwave. Do not thaw slowly at room temperature (that would foster multiplication of bacteria).
- Wash poultry inside and outside before cooking.
- Cook poultry until the internal temperature reaches 80°C (180°F). Do not cook partially and re-heat later.
- Do not leave cooked poultry on the counter for more than 1 hour.

2.Prevent contamination in food service establishments: Licensing and inspection of food service establishments with food handler certification and education.

Education of the food-handler plays a much more important role than any routine screening.

Food-handlers with acute enterocolitis should be excluded from food handling until they no longer shed *Salmonella*. The practice of requiring 3 successive negative stool samples is only justified for high risk individuals whose work involves touching unwrapped food consumed raw or without further cooking (Miller 1995). The risk posed by asymptomatic food handlers or health care workers does not justify systematic periodic screening.

Asymptomatic food handlers have not been unequivocally implicated in the causation of outbreaks. In the investigation of outbreaks, where food handlers have been found to be excreting the organism, epidemiological evidence indicates that they have acquired it during the course of the outbreak and have been victims themselves rather than the source. Thus food handlers may be transmitters while clinically unwell.

but as carriers with well formed stools, they do not constitute a much greater risk of transmitting disease via food than those workers who are not excretors of the pathogens.

3. Maintain food supply free of contaminants:

- Animals used in the production of human food become contaminated from animal feed, from other animals in the farms, in stockyards and during transportation, in the slaughter houses, in the food processing plant.
- Industrialized farming promote *Salmonella* transmission. Crowded conditions and contacts with feces favors the spread of *Salmonella*.
- Inspection of animals to be slaughtered aims at refusing moribund animals to be accepted for animal consumption. The carcass should be used for pet food or rendered into meal for animal feed.
- Rendering plants produce meat and bone meal used for animal feed. *Salmonella* bacteria survive the high temperature rendering process. Some countries, not all, require pasteurization of animal feed to prevent returning *Salmonella* to the farms through animal feed.
- Pasteurization: Milk pasteurization has had a major impact in eliminating milk borne transmission. Any egg preparation using eggs which are not thoroughly cooked should be done with pasteurized eggs.

4. Prevent direct transmission

- Mothers should be educated as to risk of transmission of *Salmonella* and of other agents transmitted by fecal oral route. Careful handwashing is necessary when handling neonates.
- Pet owners should be aware of the risks caused by their pets.
- Household contact investigation of individual cases has little benefit. It is likely that additional cases would be found (up to 60% of household have one associated case. However no action would be taken since antibiotic treatment is not recommended.

Hospital precaution and isolation: Standard precautions

Infection control precautions for health care facilities stress handwashing as the primary and most effective preventive measure. Health care workers involved in direct patient care need only be removed from work if they have enterocolitis. They may return to work after cessation of symptoms. A negative culture is not necessary unless they work in nurseries, renal dialysis or intensive care units.

Veterinary workers should wash their hands after handling pets, especially after handling feces. These workers can further reduce their exposure to feces by wearing rubber or disposable gloves, and by removing gloves and washing their hands immediately after finishing a task that involves contact with animal feces. Although there have been no reports of *Salmonella* transmission through splash exposures, workers might consider taking measures to reduce splashes of feces to the mouth when hosing or cleaning a kennel. All surfaces contaminated with feces should be cleaned and disinfected. No eating should be allowed in animal treatment or holding areas. Because use of antimicrobial agents contributes to increasing resistance and facilitates transmission of multidrug-resistant *Salmonella*, eliminating inappropriate use of antimicrobial agents may help to prevent outbreaks of multidrug-resistant *Salmonella* infections in veterinary facilities.